Managing Young Forests as Black-tailed Deer Winter Ranges

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Managing Young Forests as Black-tailed Deer Winter Ranges

by

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ABSTRACT

During snowy winters, black-tailed deer (Odocoileus hemionus columbianus) in coastal British Columbia appear to survive best in old-growth forests. Because biologists regard these old-growth winter ranges as unique and irreplaceable, the B.C. Ministry of Environment has requested no logging of the most heavily used patches. However, reserving the timber from logging forever would mean losing important economic benefits, so alternatives for ensuring deer survival have been suggested. Of these, the use of specialized silvicultural treatments of young Douglas-fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla) stands appears most promising.

On winter ranges, deer need shallow snowpacks that melt quickly, abundant understory vegetation and arboreal lichens for forage, and overhead canopies and ground-level thickets for cover. With modifications to the structure and species composition of forests, most of these features can be produced in immature stands. However, the potential for enhancing lichen establishment and growth remains uncertain.

To serve as winter ranges, young forests will need to be patchier than most intensively managed stands, and in some patches, tree densities will need to be lower than normal. Initial prescriptions for creating winter ranges should aim to produce a 60/40 ratio of cover to forage-producing areas. By selecting suitable stands, planning treatment regimes carefully, and beginning treatments early, managers can probably provide suitable winter ranges in 40- to 80-year-old stands. These ranges may be poorer (lower in carrying capacity) than prime old-growth winter ranges, but by managing larger areas, managers can compensate for lower quality with greater quantity under most winter conditions.

PREFACE

Deer needs for winter habitat, and ways to provide for these needs, have been debated vigorously in coastal British Columbia since about 1970. Resource managers and researchers have searched unsuccessfully for political and technical solutions to the competing demands of timber harvesting and deer shelter in old-growth stands. Most people agree that the best approach would be one that both maintains healthy populations of deer and allows the logging of most old-growth stands at low elevations. Silvicultural manipulation of young forests appears promising, but a detailed analysis of the potential for creating young-growth winter ranges has been lacking.

This report provides the first such analysis. In it, we summarize relevant information, describe some principles, and suggest initial prescriptions for creating winter ranges through stand management. We expect to revise the prescriptions as we learn new and better approaches.

We hope our analysis and proposals will stimulate discussion and generate more ideas on how to manage forests for winter range values. The discussion of ecological principles is comprehensive and is based on research conducted on Vancouver Island and elsewhere, but the number of literature citations has been minimized to make the text more readable. Readers wishing to obtain more information on the subject should consult reports by Jones (1975); Stevenson (1978); Harestad (1979); Hebert (1979); Rochelle (1980); and Bunnell et al. (1985).

Some of the information needed to establish an ideal winter range management system is not currently available, and has been highlighted in Sections 3 and 4.

Comments and suggestions on all aspects of the report are invited.

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1 INTRODUCTION

For the past 15 years, most of the serious conflicts between wildlife managers and the forest industry on British Columbia's south coast have arisen over the winter range requirements of Columbian black-tailed deer (Odocoileus hemionus columbianus). Certain old-growth timber stands provide critical habitats for deer living in areas that experience frequent snowfalls, so the B.C. Ministry of Environment (MOE), the branch of government charged with wildlife management, has asked for many of these critical winter ranges to be preserved. However, forest companies hold cutting rights to the timber in most winter ranges, and wish to log the old growth. The B.C. Ministry of Forests (MOF), the government agency responsible for public forest lands, must arbitrate this dispute.

Three factors make it difficult for the MOF to decide the future of specific ranges. First, cutting rights to Crown forest lands (including most wintering areas of deer) were granted many years ago to forest companies. Recent legislation, however, directs the MOF to plan the use of Crown forest resources so that the production and harvesting of timber and the realization of wildlife values are "coordinated and integrated", in co-operation with other ministries (including the MOE) and the private sector [Ministry of Forests Act, RSBC Chapter 72, Section 4(c), 1979]. With the MOE wanting to maintain deer numbers, and forest companies wanting to cut the old-growth timber that is apparently needed by deer, co-ordination and integration of resource uses is not a simple task.

Second, important public interests reside in both resources. The scale shifts sharply to favour logging when the economics of timber and deer harvests are weighed off (British Columbia Ministry of Environment and Ministry of Forests 1983); but the social, aesthetic, and other values of wildlife and standing old growth may be higher than those of logged land and stable jobs. These values, like the worth of an urban park to city-dwellers or the awe experienced by visitors to Cathedral Grove, are not easily measured.

Third, people have questioned whether deer depend absolutely on old

growth, and have pointed out that most winter studies in coastal British Columbia examined areas with old growth, recent cutovers, and very young stands (less than 20 years), but no older immature stands. Perhaps deer can survive contentedly in 60- to 80-year-old stands, they have said, or perhaps deer can be fed hay when snows cover native foods.

Faced with unreconciled policies, unmeasurable trade-offs, and unproven hypotheses, the MOF has been unable to decide whether logging or preservation of winter ranges would best serve the public interest. In most cases, a final decision has been postponed and logging deferred for unspecified periods. However, as other old-growth stands are logged, pressure mounts for a resolution to the issue. The government agencies, the private companies, and the public need to know what options are available, and what would be gained and lost with each of them.

1.1 Management Options

Managers can address the periodic, severe winter mortality of coastal deer in four ways. They can:

1. permanently prohibit harvesting of some or all of the old-growth winter ranges that are currently deferred. This would require the government to allocate the land to long-term wildlife production. The costs and benefits of this option were analyzed in a report by the British Columbia Ministry of Environment and Ministry of Forests (1983).
2. allow the harvest of some or all currently deferred winter ranges, and do nothing more; that is, accept major losses when severe winters occur, and manage deer and their habitat for high production during intervals between severe winters.
3. implement a programme of winter feeding during periods of deep snow, using non-native forage such as pelleted ration or hay.
4. use silvicultural prescriptions to create winter range in young, managed stands.

The relative merits of options (2) through (4) are summarized below.

1.1.1 Accept winter losses

Because black-tailed deer have a relatively high reproductive capability, their populations increase rapidly under favourable habitat conditions if other factors affecting population growth, such as wolf predation and hunting, are controlled. After all but the very worst winters, several consecutive mild years will allow deer populations to rebuild rapidly if other causes of mortality are not excessive. If the MOE could accept occasional short-term population crashes at low elevations, and did not want to produce deer in areas with frequent heavy snowfalls, there would be no need to have critical winter ranges.

The frequency of winters with deep, long-lasting snow cover is the key to the feasibility of this option. For example, the MOE has adopted a laissez-faire approach to deer winter range on the east and north coastal plains of Vancouver Island because it assumes there will continue to be long intervals between years of deep, long-lasting snowpacks in these areas. Heavy winter mortality once every two decades or longer is acceptable for MOE deer management programmes. On the other hand, in the mountains of Vancouver Island and the Lower Mainland, severe winters are expected to keep deer populations unacceptably low in the absence of critical winter range, notwithstanding the recent series of mild winters and the predicted warming of the world's climate due to the greenhouse effect. Unless MOE deer management objectives are revised or a change in climate is proved, critical winter ranges will remain important in many coastal areas.

1.1.2 Implement winter feeding

Winter feeding of wild ungulates has always been controversial, and has been hotly debated recently because of its extensive use in Colorado, Oregon, Utah, Washington, and Wyoming. Issues of philosophy, biology, economics, and logistics influence any manager's answer to the question: Should we feed starving deer

and elk? The arguments against winter feeding as a long-term practice are compelling:

- Philosophical: Concentrating large numbers of animals around feed depots and forcing them to rely on human handouts diminishes their wildness and reduces human enjoyment of viewing and hunting them.
- Biological: By feeding large numbers of animals through bad winters, managers may cause deer to increase, until over-utilization of native food resources in other seasons will reduce populations anyway. Also, when animals are concentrated at feeding locations, they are exposed to high risks of disease, predation, and poaching, and they may severely damage forest regeneration.
- Economical: Feeding large numbers of deer is expensive, and once begun, winter feeding must be continued in future severe winters if natural forage cannot be enhanced. Long-term costs can be a crushing burden for under-funded wildlife programmes. For example, in January 1984 the Oregon Department of Fish and Wildlife spent $21 000 per week to feed 5200 deer and 2200 elk in northeastern Oregon alone (Durbin 1984). The Oregon programme also used donated money, food, and volunteer help, but wildlife losses were still heavy, particularly in inaccessible areas.
- Logistical: Access problems severely limit the feasibility of winter feeding. Roads to many winter ranges in south-coastal British Columbia are closed in winters of deep snowfall, so a major feeding programme would require air transport of forage or extensive road plowing. Except near towns and highways, which are usually on the coast where snowfalls are lightest and feeding is least necessary, feeding programmes would be difficult and expensive.

In spite of these problems, if sufficient funds were available

winter feeding could sustain large deer populations, even if old-growth ranges were absent. However, the MOE does not plan to establish a large winter feeding operation in coastal British Columbia, and small scale projects will not solve the winter habitat problem throughout the coastal mountains.

1.1.3 Create winter ranges with silviculture

In recent years, a few foresters and wildlife ecologists have suggested that old growth may not be unique in its ability to support deer during winter, and that silvicultural treatments could be used to hasten the development of young stands into suitable winter habitats (Rochelle 1980; Hanley et al. 1984). Theoretically, such stands could replace or supplement deferred old-growth stands, which are commercially much more valuable. This assumes that age or volume alone do not determine a stand's winter habitat value, but that other factors -- including the topography of the site, the features of the tree crowns and stand canopy, the understory vegetation and arboreal lichens, and the spatial distribution of these components -- are also important.

Except for site topography, all or most of these variables could be modified by standard or specially designed silvicultural practices, including common techniques of site preparation, regeneration, and stand tending. The most effective techniques would be: 1) site preparation -- prescribed burning or mechanical disturbance to prepare the site for specific tree species; 2) regeneration -- species selection, planting density; and 3) stand tending -- fertilization, pruning, juvenile spacing (pre-commercial thinning), and commercial thinning. Section 3.4 describes the effects of these treatments more fully. In addition, several special and currently unusual practices might be employed, such as planting shrubs, spreading lichen fragments, and retaining lichen "seed-trees" during harvesting.

Stand age at first treatment will significantly influence the

likelihood of success. Stands that have experienced a period of severe crown competition will be more difficult to manage than younger, more open stands, because crowns will be shorter, lateral branch growth will be slower, and many understory plants will be shaded out. Also, winter ranges created in young stands may never attain the carrying capacity of the best old-growth ranges. Because high quality old-growth ranges are limited in area, though, the same number of deer could probably winter in a larger area of lower quality managed stands. However, some areas of southwestern British Columbia (especially above 800 m elevation) commonly receive so much snow that no forest, not even the best old growth, can provide winter range for black-tailed deer.

If young stands could provide the required winter habitat features at low to moderate elevations within an acceptable rotation period, consumers of both timber and deer would benefit. Old-growth winter ranges could be logged and replaced by younger stands that are less valuable economically, while in areas where deer carrying capacity has been low due to a lack of good winter ranges, new managed winter ranges could be developed. Even under the most radical forestry regimes, the managed areas would produce some usable wood fibre when logged, thus generating additional revenue. However, management costs over the rotation period would probably exceed those for standard forestry regimes, volume or product quality might be lower, and rotation periods might be lengthened, such that the net economic benefit from timber production could be sustantially less than the theoretical maximum. Despite some economic loss, the creation of young-growth winter ranges would not generate problems as a severe as those posed by the other three options. Silvicultural manipulation, then, appears to be the preferred alternative, if suitable habitat conditions can be achieved.

Deer are not the only wildlife living in old-growth forests, and the needs of other animals may be more difficult to provide for

in young stands. For this reason, and because of other cultural and ecological values of old-growth forests, a technical resolution of the deer winter range issue would not eliminate controversy over the allocation of old-growth stands. However, it would encourage people to more clearly define the other old-growth values (e.g., as natural "baseline" ecosystems, and as habitats for cavity-nesting birds) and would focus future discussion directly on those values, which are generally subordinated by the deer winter range issue.

1.2 Report Outline

The following sections describe the ecological background to managing deer winter habitat, and evaluate silvicultural effects on the key features of winter ranges. A system for designing and implementing a winter range creation programme is proposed, and detailed stand treatments are described that should enhance the winter range value of young stands in several climatic regions of Vancouver Island. The importance of local objectives for deer populations and habitat capabilities, and the importance of evaluating alternative sites for management before planning a site-specific regime of stand prescriptions, are also discussed.

2 WINTER RANGE CHARACTERISTICS AND USE

The term "winter range" is used by wildlife ecologists throughout the temperate and colder regions of the world, but its meaning varies greatly among species and locations. Most simply, the winter range of one or more animals is merely the area occupied during the winter months. However, in reference to a single species in a given area, the term "winter range" usually implies a special set of vegetative and topographic conditions, or a specific location that traditionally shelters large numbers of animals.

In the case of coastal deer, those who have conducted inventories and research on old-growth winter ranges have thoroughly described the typical

nature of the sites and forests, but few have analyzed the reasons deer choose these stands to winter in rather than other habitats available nearby. The available data suggest that two factors -- shallower snow and more available food -- cause deer to prefer old growth to very young stands. Old-growth snowpacks are shallower, at least in patches, because the large trees intercept snow most effectively, and also because the heterogeneous canopy modifies wind patterns, resulting in variable deposition of snow. More forage is available because rooted forage plants and arboreal lichen litterfall are abundant, and also because deer can easily move through the shallow snow to feed on the unburied vegetation.

2.1 Ideal Winter Range

Apparently, then, the common topographic and vegetative features that distinguish good deer winter ranges interact to provide decreased snow depths and increased available forage. These features can be summarized with a description of the archetype of old-growth winter range for coastal black-tailed deer:

- The site is a moderately to steeply sloping hillside (30-80% slope) of southerly aspect at low elevation (less than 800 m). Small rock outcrops or bluffs are present in portions of the stand.
- The forest cover is old growth (> 200 years), predominantly large Douglas-fir (Pseudotsuga menziesii), with lesser amounts of western redcedar (Thuja plicata) or western hemlock (Tsuga heterophylla) (especially in the lower canopy). The average canopy closure of the stand is 65-70%.
- Abundant arboreal lichens of the type commonly called old man's beard (Alectoria, Bryoria, or Usnea species) are present in the crowns of the large trees.
- The understory vegetation includes many different species but is dominated by salal (Gaultheria shallon) and red huckleberry (Vaccinium parvifolium), often with small western redcedars and lesser amounts of other forage plants such as wild rose (Rosa spp.) and Oregon-grape (Mahonia nervosa).

- In vertical structure and areal distribution, the stand is variable, with small openings, densely canopied patches, and understory hemlock or cedar thickets mixed with more uniform areas of moderately dense (70-80%) canopy.

This is an idealized description that applies best to central and southern Vancouver Island, and considerable variability exists among actual ranges. Differences are particularly evident in wetter and cooler biogeoclimatic subzones where western hemlock and amabilis fir (Abies amabilis) become more important in the forest canopy and salal decreases to be replaced by plants such as Alaskan blueberry (Vaccinium alaskaense), oval-leaved blueberry (V. ovalifolium), sword fern (Polystichum munitum), deer fern (Blechnum spicant), bunchberry (Cornus canadensis), and five-leaved bramble (Rubus pedatus). In fact, on much of Vancouver Island winter range canopies are composed entirely of various mixes of western hemlock, amabilis fir, and western redcedar, with no Douglas-fir. Therefore, although evidence indicates that Douglas-fir is the coastal species that intercepts snow most efficiently in young stands (see Section 3.2.1), it appears that species composition of the overstory is not the most important characteristic of winter ranges.

If it is recognized that substantial variability occurs in nature, the idealized winter range can provide a useful model for defining desirable characteristics for young, managed stands.

2.2 Patterns of Winter Range Use

Even though old-growth ranges as described above are known to be preferred deer habitats during periods of deep, uncrusted snow, deer use and need of such stands vary greatly among areas, among winters, and even within winters. For example, lowlands, coastal plains, or low-elevation mountains border the ocean around most of the perimeter of Vancouver Island. Here, deep and persistent snowpacks are infrequent (although not unknown), and old-growth stands are not regarded as

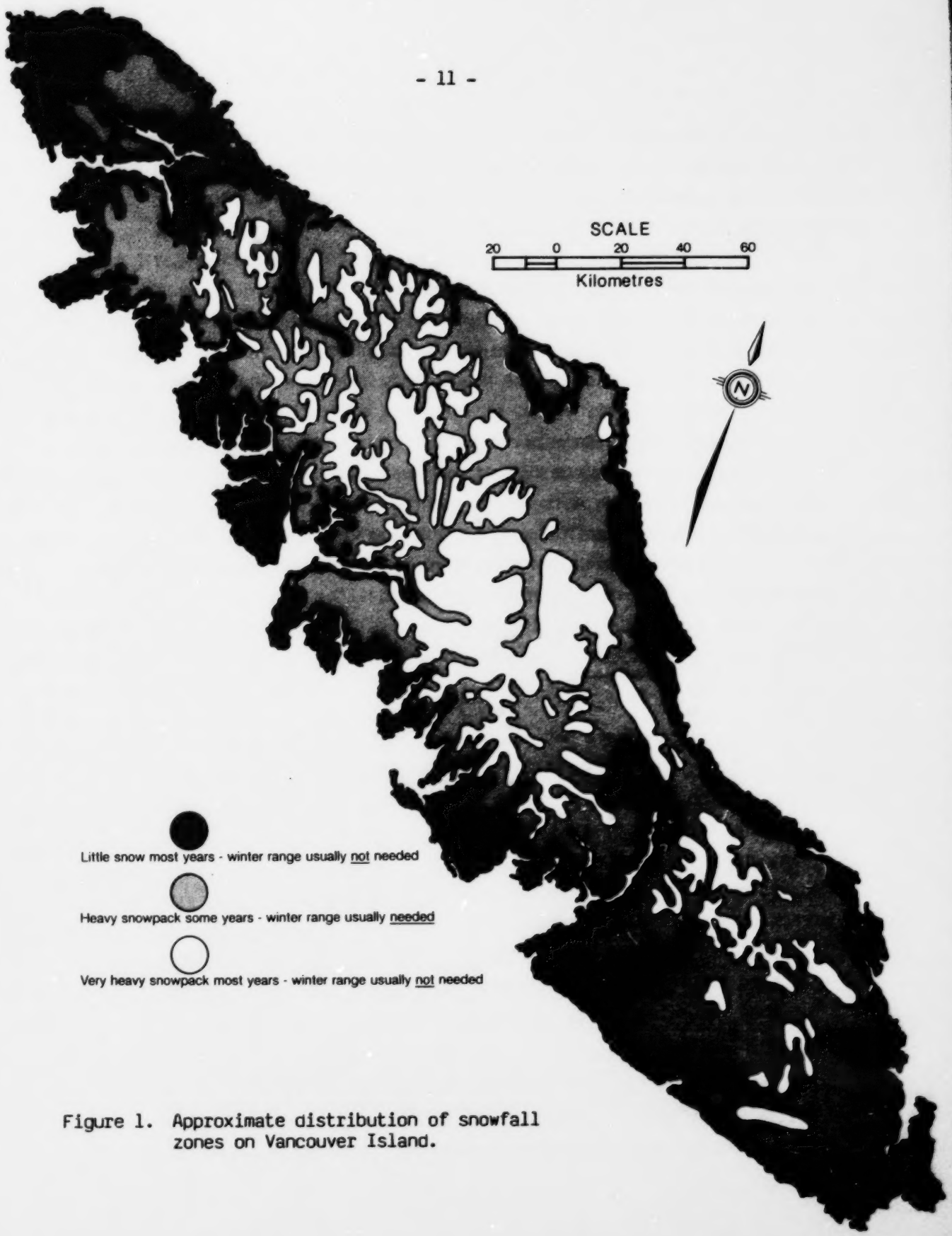
critical habitats in most years (Hebert 1979). On the other hand, at elevations above 800 m throughout the Island, snowpacks are so deep in most winters that deer use is minimal, again making winter habitat unimportant. Thus old-growth winter ranges, or younger imitations of them, are only needed in the intermediate areas between the coastal lowlands and the mountain heights above 800 m elevation (Figure 1). Most of this report concerns these intermediate areas, which have heavy snowpacks in some years.

Winter-to-winter variations in weather can modify the typical temporal and spatial patterns of deer concentration. In some years, heavy snows on the coastal plain may drive deer into restricted areas; while in other years, mild temperatures in the inland mountains may free the animals to use all but alpine habitats. Harestad (1979) concluded that deer gain an adaptive advantage by staying away from critical ranges during mild winters because forage is conserved for winters when it is needed most. Also, deer commonly move on and off a given winter range numerous times during a winter as the weather alternates between cold, snowy conditions and warmer spells with little or no snow. It is not clear why most deer leave winter ranges so rapidly once the snowpack begins to melt, but it is likely that they prefer to forage elsewhere when not restricted by snow (Bunnell and Jones 1984).

Despite this variability in use, black-tailed deer undoubtedly need special habitats so they can conserve enough energy to survive deep, long-lasting snowpacks and reproduce successfully the next spring. Winters with persistent deep snow do not occur every year, but history indicates that they occur with sufficient frequency to make winter range the major deer habitat concern over much of Vancouver Island and the southern mainland coast.

3 DEVELOPING STAND PRESCRIPTIONS

When treatments are prescribed to encourage characteristics in young stands that will mimic the key features of old-growth winter ranges,


SCALE
20 0 20 40 60
Kilometres
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Little snow most years - winter range usually not needed
Heavy snowpack some years - winter range usually needed
Very heavy snowpack most years - winter range usually not needed

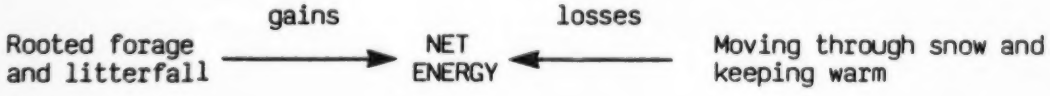
Figure 1. Approximate distribution of snowfall zones on Vancouver Island.

climatic and biological influences on range quality must be considered. Section 3.1 reviews the importance of climate and biology in setting prescriptions, and Section 3.2 provides examples of treatment regimes thought to be suitable for two stand types.

3.1 Tradeoffs and Their Influence on Prescriptions

Because stand conditions and site productivity vary throughout the snow belt of Vancouver Island and the lower coast, no overall approach for winter range creation can be prescribed. Also, environmental factors exert different degrees of influence on deer numbers in different areas of the snow belt, depending on local climate.

Energy, a common currency that expresses the influence of each environmental factor on deer health, can be used to rank the factors geographically. Deer gain and lose energy continuously, and their survival and reproduction are related to their net energy balance. This balance can be expressed simplistically as:



Deer can obtain the same net energy by increasing their energy gain (forage intake) or by decreasing their energy losses (moving less, moving through shallower snow, or conserving heat). Factors controlling the energy balance are unequal: they differ in their importance among areas, and the effectiveness of forestry treatments differs among factors and among areas. These relationships imply that, in setting prescriptions for winter ranges, managers should:

1. evaluate all five major factors influencing deer (Section 3.2), then try to increase gains and reduce losses simultaneously, rather than focussing effort on a single factor (e.g., forage or snow interception).
2. recognize that prescriptions will differ among areas, because there are geographic differences in the environmental factors (such as

the frequency of deep snowpacks); and among stand types, because forestry treatments will be more effective in some stands than others (e.g., more options are available for treating 15-year-old stands than for those aged 60 years).

3. regard current prescriptions as the first step in a process of adaptive management. There may be errors in the models presented here, so managers should evaluate the success of prescriptions for trial areas, monitor all new projects, and incorporate insights into revised prescriptions.

3.2 Models of Factors Controlling Deer Numbers on Winter Ranges

Five key factors influence deer on winter ranges: 1) snow depth and duration; 2) abundance and height of rooted forage; 3) composition and rate of lichen and foliage litterfall; 4) amount and quality of security cover; and 5) amount and quality of thermal cover. Prescriptions should reflect the importance of each factor in controlling deer and the feasibility of using silvicultural practices to modify the factors. Each of the key factors is described in detail below.

3.2.1 Snow depth and duration

Deep, soft snowpacks dramatically increase the energy costs of deer movement (Parker et al. 1984) and also bury rooted forage. Both effects reduce net energy for the deer; consequently, herd productivity declines and deer mortality increases. Rates of snow melt influence the duration of the snowpack and, thus, the duration of unfavourable conditions.

Silvicultural prescriptions on a winter range should reduce snow depth on the ground during winter and increase melt rates in the spring. The ideal topographic features noted earlier (e.g., elevation, slope, aspect, rocky outcrops) are not subject to the forester's control, but those features, together with shading from adjacent mountains, determine where forestry prescriptions will prove most successful. Foresters can control snow depths and melt

rates by manipulating the tree canopy. At least 16 features of the overstory influence snow interception and can be modified by forestry practices (Bunnell et al. 1985), but four features have an overriding influence:

1. Species composition of the overstory strongly influences the amount of snow interception by young stands because of species-specific attributes of branch angle, branch flexibility, interwhorl distance, and height-to-base ratio of the crown (the ratio of the length of live crown to maximum crown width). Under all but the wettest snow conditions, Douglas-fir will intercept snow most efficiently. Its branches, more rigid or more horizontally oriented than those of amabilis fir, hemlock, or redcedar, provide flat "platforms" which can hold large amounts of snow. Once branches are depressed by heavy loads of snow, the height-to-base ratio of the crown governs the degree to which snow is shed. This ratio is smaller in Douglas-fir and more favourable to interception. Because Douglas-fir holds more snow in its crown, melt directly from the crown is more important than in hemlock or redcedar stands.

   Species composition can be modified by site preparation before establishment, by planting, or by retaining preferred species during spacing and thinning. All silvicultural practices that modify tree spacing and growth rates will alter height-to-base ratios, interwhorl distances, and branch angles.

2. Patchiness of the stand affects both the distribution of snow on the ground and melt rates. Because of their influences on wind patterns and velocity, openings of one-half to one tree-height in diameter will produce areas of shallower snow near the openings. The openings will be most effective if an intermediate or suppressed stratum is retained on the downwind side. Subcanopy strata can enhance the effect of wind in "stealing" snow from the canopy overhead, but this seldom

occurs with wet, coastal snow. During warm periods, snow will melt rapidly in openings exposed to direct sunlight, but small openings are often shaded by adjacent trees due to the low sun angle in winter.

Openings can be created by deliberately not planting small patches, and can be recleared or expanded when spacing or thinning.

3. Crown size and form affect snow interception. For maximum interception, overstory crowns should be long and wide with interwhorl distances of about 70 cm. Crown length is important because snowflakes normally approach crowns at an angle; crown width is important because both surface area and height-to-base ratios influence interception; and interwhorl distance is important because it governs the effectiveness of wind in packing falling snow into the interior of the crown. These crown characteristics can be manipulated by controlling stem density (e.g., initial stocking, spacing, thinning) and growth rate (e.g., fertilization).
4. Canopy closure also affects interception. Harestad and Bunnell (1981) and Bunnell et al. (1985) have shown that crown closure predicts total snowpack well across a variety of coniferous forest types. Because crown closure also affects melt rates, a dense but not completely closed canopy (70-90% crown closure) will be most effective at reducing the combined effect of snowpack depth and duration. Again, silvicultural practices modifying stem density and crown growth rates can control crown closure.

These four overriding factors -- composition, patchiness, crown shape, and closure -- can be manipulated through stand establishment and stand tending practices.

3.2.2 Rooted forage

For rooted forage, the objective should be to provide tall,

dense, productive, and digestible browse sufficient to feed the target number of overwintering deer. About 92 kg of forage should sustain a 35-kg adult doe through a 4-month winter, even if she was totally deprived of food for 20 days. She would lose weight, but should survive if her condition was good in the fall.

The most important winter foods for black-tailed deer on Vancouver Island and the Lower Mainland are listed in Table 1. Although trees and tall shrubs provide most of the available forage when snow is deep, low-growing herbs such as bunchberry and five-leaved bramble provide higher quality foods and are important during low-snow periods. Managers should aim to provide a mixed diet for deer, rather than attempting to enhance only one plant species throughout the whole of a winter range.

Increasing closure and volume of the tree overstory reduces the abundance of browse through competition for light, moisture, and nutrients. The degree and form of the relationship differs among sites. For some species, like salal, large openings on drier sites will be ineffective at producing winter forage, because salal height growth will be suppressed in the direct sun. Small openings of one-half to one tree-height encourage both shrub productivity and height growth, although they may also be susceptible to dominance by bracken fern (Pteridium aquilinum) which provides no winter forage. In the most extreme winters small openings will fill in with snow, particularly at the edges, and forage under the canopy will be more accessible. For the key browse species (huckleberry and salal) crown closures of 30-60% will provide optimum conditions for forage production.

Opening sizes, locations, and crown closure are all subject to the forester's control through planting densities and stand tending.

3.2.3 Litterfall forage

When heavy and frequent snowfalls cover much of the rooted forage, surviving black-tailed deer consume large amounts of

TABLE 1. Important winter foods for Columbian black-tailed deer in southern British Columbia

Latin name	Common name
(A) Trees	
Pseudotsuga menziesii	Douglas-fir
Taxus brevifolia[a]	Western yew
Thuja plicata[a]	Western redcedar
Tsuga heterophylla	Western hemlock
(B) Shrubs	
Acer circinatum[a]	Vine maple
Amelanchier alnifolia[a]	Saskatoon
Gaultheria shallon[a]	Salal
Rosa spp.	Wild roses
Rubus ursinus	Trailing blackberry
Salix spp.	Willows
Vaccinium alaskaense	Alaskan blueberry
Vaccinium ovalifolium	Oval-leaved blueberry
Vaccinium parvifolium[a]	Red huckleberry
(C) Ferns	
Blechnum spicant[a]	Deer fern
(D) Herbs and half-shrubs	
Carex spp., *Poa* spp., etc.	Various sedges and grasses
Cornus canadensis[a]	Bunchberry
Linnaea borealis[a]	Twinflower
Rubus pedatus	Five-leaved bramble
(E) Lichens	
Alectoria spp.[a]	
Bryoria spp.[a]	

[a] These species are commonly regarded as being the most important and/or preferred winter foods.

litterfall, primarily arboreal lichens of the Alectoria, Bryoria, and Usnea genera. Lichens may be a critical source of energy under these conditions.

Arboreal lichens grow most abundantly in old-growth stands on certain favourable sites, but also occur in stands as young as 10-15 years, especially when old growth occurs nearby. Usually, young stands contain insufficient amounts to provide winter forage for deer. Among the factors that may limit lichen abundance in young growth are: 1) slow rates of dispersal from areas of high abundance to newly established stands; 2) maximum rates of growth that are intrinsically slow, even under favourable growing conditions; 3) substrate (i.e., bark or foliage) conditions on young trees that do not allow the initial establishment of lichens; and 4) unfavourable microclimatic conditions that cause lichens to grow slowly once they are established.

Although there have been few studies of lichens in British Columbia, evidence suggests that neither slow intrinsic growth rates nor restricted substrate tolerances are the causes of limited abundance. The other factors, slow dispersal and unfavourable microclimates, appear equally probable at present and both may have important effects on standing crops of forage lichens in young stands.[1]

Two potential solutions to the problem of slow dispersal have been suggested. One is to encourage the natural dispersal of forage lichens by choosing young stands for management near sources of abundant lichens, such as unharvested patches of suitable old growth (preferably within 200 m). Natural dispersal could be further enhanced by retaining lichen-loaded veteran trees or snags

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1 Stevenson, S.K. 1985. Enhancing the establishment and growth of arboreal forage lichens in intensively managed forests. Problem analysis. B.C. Min. For., Research Branch, Victoria, B.C. Unpublished report.

during harvesting or thinning. Alternatively, lichens could be dispersed artificially, such as with the aerial spraying of thallus fragments over a stand, using a helicopter and modified fertilizer bucket.

Alectoria, Bryoria, and Usnea seem to require forest microclimates characterized by moderate to high levels of solar radiation in the lower canopy and frequent wetting/drying cycles. These conditions typically occur in old-growth canopies because of the slow growth of live trees and frequent canopy gaps caused by dying trees. Younger stands, however, more often have closed, dark, lower canopies and more stable humidity. Conditions in the upper canopies of dense, thrifty stands are also usually unfavourable because branches are soon overtopped and shaded. Better lichen growth could be encouraged in young stands if they were kept open through much of the rotation period, with either one very heavy pre-commercial thinning or a series of lighter thinnings.

Even if high lichen biomass can be achieved in young stands, however, the amount of lichen that would be available to deer is still uncertain. In old-growth stands the weak branches of old trees, with their attached lichens, break and fall to the ground during windy and snowy conditions. Rochelle (1980) found that, during winter, this process provided more forage from lichens than was available from rooted plants in four of five old-growth stands he studied in the Nimpkish Valley. In thrifty, young-growth stands, litterfall rates would probably be much lower, particularly if the stands were kept open to promote the suitable microclimate. Dead lower branches on young trees often hold the most lichens, and these branches could be retained (i.e., not pruned) to provide a small amount of lichen litterfall as the branches decay.

3.2.4 Security cover

Deer prefer vegetative cover for some activities (e.g., resting and fawning) and appear to derive a sense of security from it, but the importance of cover to deer survival and reproduction

is difficult to quantify. The elements of cover that permit smaller animals to evade predators do not seem to benefit deer pursued by wolves and cougars. Nevertheless, security cover is important to deer in escaping hunters.

The objectives in prescribing winter range treatments should be to maintain some escape or security cover in managed stands and to encourage more where feasible. Managers can manipulate four features of security cover patches: visual density, physical complexity, size, and shape. Visual density provides concealment, while the physical complexity of an area that is known intimately by the deer provides opportunities for evading predators. However, unless forage is available nearby, deer are unlikely to use large, dense thickets intensively, or come to know them well. Thus, size and shape of cover patches may be more important than the total area of security cover available.

Topographic relief such as gullies, ridges, and rock outcrops will supplement vegetative cover, but there will seldom be sufficient topographic variability to satisfy all cover needs. The micro-relief of a winter range site should therefore be regarded as a bonus to deer, rather than a tradeoff with stand conditions.

Understory thickets of redcedar or hemlock provide the best security cover. Foresters can control this cover during site preparation by retaining young residuals; during regeneration by deliberately stocking limited areas densely; and during stand tending by retaining dense patches of understory trees. Even tall, dense salal, which can be maintained by keeping the canopy open, can provide security cover in areas where conifer thickets are difficult to provide.

3.2.5 Thermal cover

Under some conditions, deer must devote a considerable portion of their ingested energy to regulating body temperature. Preliminary estimates for weather conditions on Vancouver Island

suggest that this energy requirement is approximately equivalent to the cost of recovering from a 25% overwinter weight loss or to 20-80% of the cost of producing one fawn.[2] If winter thermal cover is available, deer expend less energy in keeping warm. In dry, still air black-tailed deer are unlikely to require excess energy to maintain body warmth in winter unless the air temperature declines to -10 to -15^{o}C (uncommon on the coast). The lower critical temperature, however, rises with increasing wind speed and wetting. Thus thermal cover prescriptions should address three abiotic components influencing an animal's thermal environment: radiation, wind speed, and rainfall interception.

Any forest canopy acts as a thermal blanket and increases the downward flux of thermal radiation towards the forest floor; winter nighttime temperatures are therefore warmer under a canopy than in the open. Because canopy permeability increases rapidly as trees are removed, lower canopy closure means poorer nighttime thermal cover. To provide good thermal cover, the canopy must be more or less complete, and high enough ($\geq$ 4 m) to trap longwave radiation at deer height. Abundant foliage near the ground reduces wind speeds, so winter thermal cover will be enhanced by coniferous crowns extending to the ground or by a dense evergreen understory. Rain interception is affected primarily by surface area of the crown, so length and closure of crowns are the most important factors. Shade-tolerant species, including western hemlock, amabilis fir, and western redcedar will reduce the combined chilling effects of wind and rain better than Douglas-fir, because of their denser canopies. In contrast to the advantages of dense canopies during wind and rain and at night, unshaded openings in the

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2 Bunnell, F.L., K.L. Parker, L.L. Kremsater, and F.W. Hovey. 1985. Thermoregulation and thermal cover of deer and elk on Vancouver Island. Problem analysis. B.C. Min. Environ. and Min. For., Victoria, B.C. Unpublished report.

forest can also be important because direct sunlight warms deer even when temperatures are low.

Thinning reduces a stand's effectiveness at trapping thermal radiation. Under the normally mild coastal conditions, this effect may be compensated somewhat by reduced wind speeds resulting from the understory growth that thinning encourages. Thickets reduce wind speed, intercept rainfall, and trap longwave radiation, and will be the most effective means of providing winter thermal cover. Openings that are large enough to be unshaded at low solar angles will provide favourable thermal environments during daytime.

3.3 Relationship of Site Location to Prescriptions

The relative importance of the five key factors influencing deer on winter ranges varies within stands and among stands and watersheds. Managers should consider both the influence of each factor on deer and the control exerted by the forester on each factor. Three hypothetical examples illustrate these points:

1. In an area of southeastern Vancouver Island with a relatively warm and dry climate, potentially high salal production, and 1 year of deep, long-lasting snow in every 10, snow depth and duration would be a concern only at higher elevations; thus, no management to increase snow interception would be prescribed for most of the area. Rooted forage would be the major concern, making the timing and intensity of thinning treatments important. Arboreal lichens could be encouraged by retaining lichen sources, but would not be a high priority due to the infrequent heavy snowpacks. Sufficient security cover, distributed in an appropriate pattern, would be needed to enable deer to use the rooted forage and to escape hunters in this area of heavy recreational use. Thermal cover would be of concern primarily during spring and summer, and could be provided by security cover patches.
2. In an area similar to (1) above, but with more rain, such as lower

elevations on the west coast of Vancouver Island, snow would again be unimportant at low elevations, but would fall heavily at higher elevations during cold winters. At lower elevations, rooted forage production would therefore be the highest priority, so most stands should be thinned frequently or heavily. Above 500 m, closed tree canopies, large trees, and abundant lichens would be needed. Frequent rain and cool temperatures would make thermal cover valuable. The proximity of young stands to old growth and the retention of lichen-bearing trees and snags during logging would be important, as would the distribution of security cover patches across the area. Young, unthinned stands would serve as both thermal and security cover. In most years, thermal cover would be more important than snow interception.

3. In an area of north-central Vancouver Island where both salal and Vaccinium are highly productive and moderate to severe winters occur two or three times each decade, deer movement through snow would be a more common problem than farther south. Management prescriptions would therefore emphasize snow interception. Most of the winter range area should have a closed canopy and large trees, so heavy thinning at an early age or repeated lighter thinnings would be desirable. Rooted forage, also important, could be provided in heavily thinned patches and small openings, if they were located close to areas of closed canopy where deer could move more easily. To encourage arboreal lichen forage, lichen sources should be provided near or in the managed winter range. Security cover and thermal cover would be less important than snow interception and forage availability, but could be provided by understory thickets of western hemlock, amabilis fir, or redcedar.

3.4 Influences of Forestry Practices

Section 3.2 discussed the influences of forestry practices on factors governing deer capabilities of winter ranges. In summary, foresters can use the following techniques to control stand conditions

through the rotation period:

- Harvest -- Where stand conditions and topography permit, harvesting operations can maintain both lichen-bearing older trees and young hemlock or redcedar. Redcedar and lichen are prime forages and both should be scattered through winter ranges in high snowfall areas. Young hemlock residuals with live crowns reaching to ground level would provide cover for a few years, but would only be valuable if clumped. By the time the new stand was able to function as winter range, the crowns of the residuals would probably have "lifted-off" and would no longer provide cover, but the dense stems of the trees might provide sufficient concealment. Also, hemlock seedlings arising from seedfall from the residuals could be encouraged, to provide new thickets.
- Site preparation and regeneration -- Retention of redcedar and patches of hemlock residuals are important as noted under harvest. Among the species available for planting or natural regeneration, Douglas-fir will intercept snow most efficiently, but small patches of hemlock (cover) and redcedar (forage and cover) would be valuable in all areas, and may, with amabilis fir, be the only species available for sites unsuited to Douglas-fir. Small areas ($\leq$ 0.5 ha) of all four species with high stocking rates would eventually provide thermal cover, and small redcedars would provide forage as well. Security cover could be provided by understory patches of dense hemlock. Sites should be prepared to suit Douglas-fir wherever it can grow properly, especially in areas of frequent heavy snowfalls. However, if small patches of relatively undisturbed organic soil could be retained to encourage redcedar or hemlock beneath the Douglas-fir overstory, the winter range would be of higher quality.
- Stand tending -- Dense thickets, particularly of hemlock and redcedar, can be maintained for cover. Spacing, thinning, and fertilization could be used to increase tree size (hence snow interception) and understory forage. Herbicide treatments or

manual brushing would usually be unnecessary on winter range sites, but if needed they should be applied at the base of crop trees rather than throughout the whole area, so as to maintain forage between trees. Regimes would differ among sites depending on the relative importance of snow interception and browse production. Where deep snowfalls are frequent, the desired canopy closure would be higher, or a larger proportion of the winter range area would be allocated for dense canopy, than in areas where deep snow is infrequent. Both browse production and snow interception would benefit from openings one-half to one tree-height in width. Areas of very low final spacing (<100 stems per hectare) could encourage browse production, but would not maximize snow interception. The best compromise is a pattern of small patches of dense canopy interspersed with more open patches, providing an optimum mix of shallow snow and abundant food in close proximity.

3.5 Criteria for Prescriptions

Preceding sections have raised three issues that shape the content of prescriptions for specific areas. First, snow depth and duration are dominant factors in setting prescriptions. Snow characteristics determine the relative priority assigned to each controlling factor (e.g., rooted forage or thermal cover versus snow interception or arboreal lichens), and indicate the likelihood of success in providing some key elements of winter range (e.g., rooted forage is subject to snow burial).

Second, more than one characteristic of a forest stand may influence the environmental factors that determine the value of the stand as winter range (e.g., the closure, size, and form of tree crowns all affect snow depth on the ground).

Finally, the same stand feature may be affected by a number of different forestry practices, so managers may be able to choose from among a number of alternative prescriptions or regimes.

In summary:

1. Winter severity determines the relative effect of the environmental

factors on deer numbers.

2. Different stand features exert varying degrees of control on environmental factors.
3. Different forestry practices exert varying degrees of control on stand features.

Table 2 ranks environmental factors influencing deer numbers; Tables 3 and 4 indicate the stand features and forestry practices that would most strongly influence the environmental factors.

The rankings assigned to forestry practices in Table 4 are contestable in some cases. For example, it could be argued that, in attempts to ensure patchiness of a stand at 60 years of age, thinning would be more important than initial stocking because variety could be introduced to a uniform stand with thinning at any age. Initial stocking was ranked higher in Table 4 because the presence of thickets (one necessary component of patchiness) depends on dense stocking of some areas, and thinning would not be able to correct for a lack of densely stocked areas. Throughout the table, the practice that apparently provides the greatest ultimate control of each stand feature was ranked highest. The ratings are intended to provide general guidance in designing forestry regimes, but for any specific area the advice of an experienced local silviculturist should be sought.

The manager can maximize options for producing deer winter range in young stands by planning the management of a site as early as possible, preferably even before harvest of an existing old-growth stand. Many of the potentially valuable options listed in Table 4 -- such as retention of veterans or variations in site preparation, species choice for regeneration, and initial stocking density -- are no longer available after the first few years of the rotation period. Due to changes in tree physiology and structure with age, other practices become less effective in the 10-20 years following stand establishment. For example, as crown competition becomes severe, crown lift-off will limit a stand's utility because short crowns are less effective at intercepting snow. Also, rooted forage will decrease in abundance and

TABLE 2. Importance ratings of environmental factors influencing deer numbers as affected by winter severity

	Winter severity[a]		
Environmental factor	Low	Moderate	High
Snow depth	4	1	1
Snowpack duration	5	3	2
Rooted forage	1	2	4
Litterfall forage	6	4	3
Security cover	2	5	6
Thermal cover	3	6	5

[a] 1 = most important.

TABLE 3. Importance ratings of stand features as they affect key environmental factors of winter range

Environmental factor	Stand features affecting environmental factors[a]	Importance ratings of stand features[b]
Snow depth	Crown closure	1
	Crown size and form	2
	Patchiness (presence of openings)	3
	Species composition of overstory	4
Snowpack duration	Crown closure	1
	Patchiness (openings)	2
Rooted forage	Crown closure	1
	Patchiness (openings)	2
	Species composition of overstory	3
	Amount of humus and decayed wood in soil	4
Litterfall forage	Presence of veteran trees with lichen	1
	Crown closure	2
	Presence of dead lower branches in overstory	3
Thermal cover	Crown closure	1
	Presence of understory conifer thickets	2
Security cover	Presence of understory conifer thickets	1
	Height to base of live crown	2
	Overstory tree density	3
	Density and height of salal or other evergreen shrubs	4

[a] When a feature is listed several times, its effect on deer may vary; e.g., greater crown closure will reduce snow depth but will increase snowpack duration. See Section 3.2 for details.

[b] 1 = most important.

TABLE 4. Importance ratings of forestry practices as they affect stand features

Stand feature	Forestry practices affecting stand features	Importance ratings of forestry practices[a]
Crown closure	Initial stocking	1
	Thinning[b] intensity	2
	Fertilization	3
Patchiness (presence of openings and thickets)	Site preparation	4
	Species choice for regeneration	3
	Initial stocking	1
	Thinning intensity and pattern	2
Presence of veteran trees with lichen	Retention when harvesting	1
	Retention when thinning	2
Species composition of overstory	Site preparation	2
	Species choice for regeneration	1
	Species choice when thinning	3
Presence of dead lower branches	Initial stocking	2
	Thinning intensity	3
	Pruning	1
Height to base of live crown	Species choice for regeneration	4
	Initial stocking	2
	Thinning intensity	1
	Pruning	3
Crown size and form	Species choice for regeneration	3
	Initial stocking	2
	Species choice when thinning	4
	Thinning intensity	1
	Fertilization	5
Tree density	Site preparation	2
	Initial stocking	1
	Thinning intensity	3
Soil content of humus and decayed wood	Site preparation	1
Evergreen shrub density and height	Site preparation	1
	Initial stocking	3
	Thinning intensity	2

[a] 1 = most important. For each stand feature, practices are listed in sequence as they would normally be applied to a stand.

[b] "Thinning" here means both juvenile spacing (pre-commercial thinning) and commercial thinning.

variety, further reducing the stand's potential. Although thinning and fertilization can help to restore crown length and understory abundance, and may therefore provide some winter range value in older second-growth stands, it is unlikely that a management regime beginning when a stand is past 25 years of age will be as effective as a regime beginning at the time of harvest, unless the site quality for trees is poor and tree growth is slow.

Deer management objectives (for population size or habitat capability) and alternative sites to be managed should be evaluated before the planning of a site-specific regime is begun. A recommended procedure for evaluating the management context of a site is given in Section 4.

The criteria for prescription development as described above should be evaluated in preparing a forestry regime for deer winter range creation on a specific site. With a site selected and a habitat goal determined, the manager should consider:

- the winter severity index for the area and the environmental factors to be modified, as indicated in Table 2.
- the stand features needed to modify or supply the important environmental factors. Table 3 and Section 3.2 describe the desirable features.
- the age and current condition of the stand. This will determine the stand features that already exist or are needed, and the forestry options available.
- the appropriate forestry practices to provide the stand features needed (Table 4).

Using this approach, managers can determine the appropriate stand conditions for broad regions of Vancouver Island and the south coast, and can select, from the range of forestry treatments available to them, the most suitable options for achieving those conditions. Existing site and stand conditions, plus the knowledge and skill of managers, will determine the detailed treatment for specific sites.

A winter severity index must be developed, and severity zones must be mapped for Vancouver Island and the south coast, before forest and wildlife managers can institute the systematic approach recommended here.

3.6 Example Prescriptions

The desired features of an ideal winter range in a young forest, ranked in descending order of priority, are:

1. suitable topography, as noted on page 8.
2. overstory of Douglas-fir (preferred) or hemlock-amabilis fir.
3. closed canopy of long, wide crowns over about 60% of the area.
4. about 5% of the area in small openings (15-40 m in width).
5. open canopy of long, wide crowns over about 35% of the area, ($\leq$ 60% crown closure).
6. abundant forage lichens dispersed throughout the stand.
7. about 5% of the area in coniferous thickets under the canopy. These thickets ideally would be next to openings on downwind or downhill sides.

The last six features are, to varying degrees, subject to control by the forester.

Two examples of stand prescriptions will illustrate how the recommended conditions could be achieved:

- The first stand is 40 years old, situated on suitable topography on the southern portion of Vancouver Island. It has a mean dbh of 30 cm (dominants and co-dominants) and is about 25 m tall. Because the area experiences moderately severe winters, the dominating environmental factors are snow depth and rooted forage (Table 2). The prescription should produce a stand which, some years after treatment, will approximate the ideal structure of winter range. Components of the prescription are:
  - Thin 60% of the stand to 150-175 stems per hectare, prune to 5.5-11 m above the ground. This treatment should generate a stand capable of intercepting significant amounts of snow once

the canopy has closed. The stand could be thinned heavily once, or lightly several times, but crowns should not be allowed to close until the stand density is down to the prescribed level.

- Create openings or maintain existing openings of one-half to one tree-height in width over 5% of the area. This treatment should promote snow redistribution around the openings, and enhance understory forage production in and near them.
- Leave coniferous thickets under the canopy on 5% of the area. These thickets should be 30 m or greater in width and dense enough to hide 90% of a deer at 15 m. The thickets will provide security and thermal cover.
- Where possible, locate small openings near thickets to provide security cover adjacent to the prime foraging areas.
- Thin 35% of the area to 100 stems per hectare. This will encourage long-term rooted forage production. A single heavy thinning could be used, or a series of lighter thinnings, but crowns should not be allowed to close while the stand is to function as winter range. If the understory of rooted forage is currently poor, then an initial heavy thinning would be desirable to encourage rapid growth of existing vegetation and maximum recolonization of the understory. Pruning to 5.5 or 11 m above ground could accompany thinning.
- Maintain veterans or snags with lichens during thinning (at least two per hectare), to encourage lichen forage.

An appropriate pattern for this prescription would be that depicted in Figure 2, where the dense-canopy forest forms a background grid of low snow depths within which the other treatments are set. This pattern will provide deer with access through the shallowest snow to all other features of the winter range. Rectangular clearings are shown with their long axes oriented north-south to ensure that their upper portions are out of the shade of downslope trees and therefore receive maximum sun.

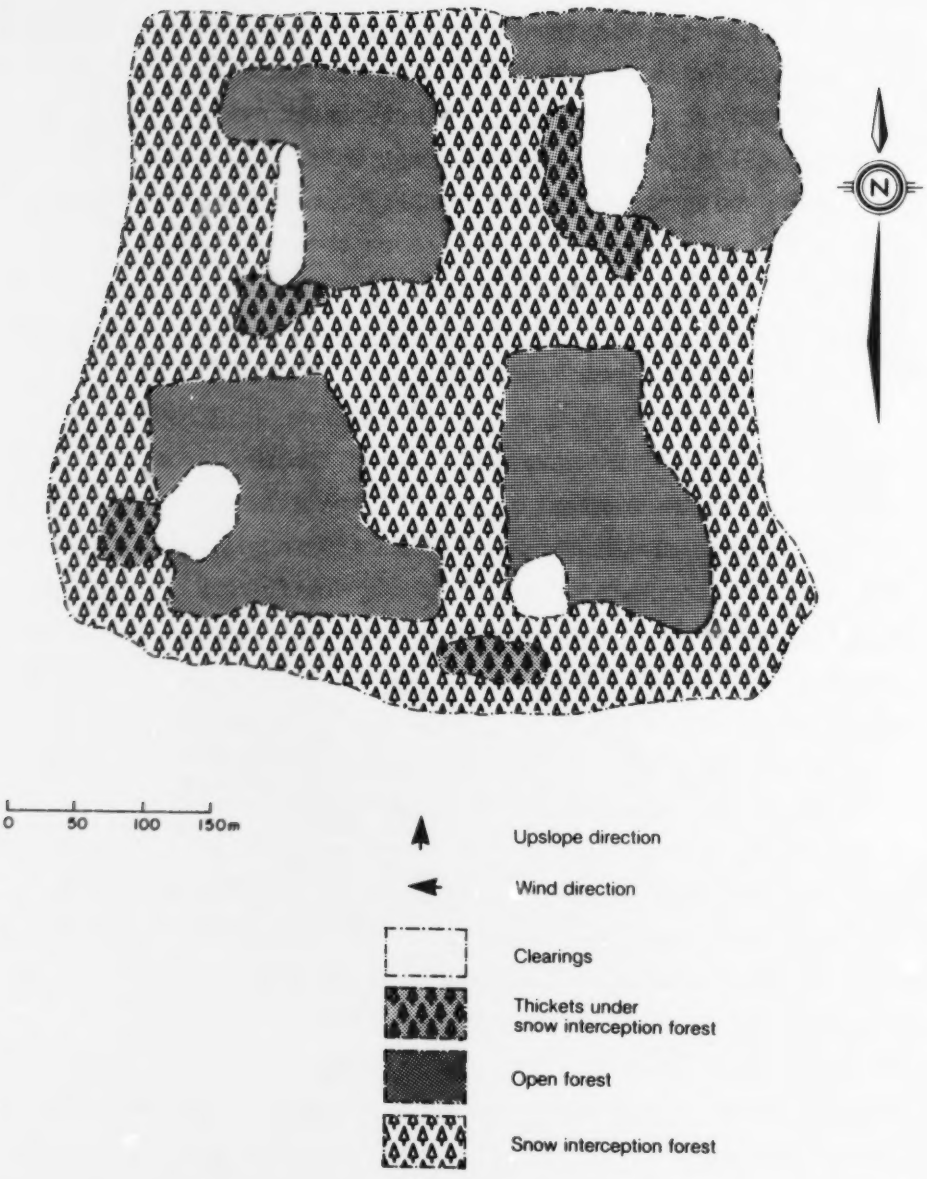

FIGURE 2. One possible pattern for the distribution of treatments within a managed winter range.

When rock outcrop openings are to be enlarged, the desired rectangular shape can be achieved by removing shading trees downhill while maintaining trees uphill of the outcrop, where enhanced forage and decreased snow would encourage heavy deer use.

Open forest patches adjoin clearings on north (uphill) and east sides to ensure maximum penetration of warmer afternoon sun into these forage-producing areas. All clearings have dense forest on at least one side so deer can reach the edge of the clearing and its rooted forage under most snow conditions. Thickets are placed on the downwind side of some clearings to enhance the effect of wind in "stealing" snow from the canopy overhead.

The second stand is 20 years old, also situated on suitable topography, in the central portion of the Island. It has a mean dbh of 12 cm (dominants and co-dominants) and is about 10 m tall. The area experiences winters of high severity and the dominating environmental factors are snow depth, snow duration, and litterfall (Table 2):

- Space or thin 55% of the stand to 250-300 stems per hectare, but do not prune. This will encourage snow interception by the canopy and lichen growth on the lower branches.
- Create openings or maintain existing openings one tree-height in width over 5% of the area. This will encourage snow interception in the adjacent forest and browse production plus early snow melt in the openings. These openings would need to be expanded as the stand grows, to maintain their width at one tree-height.
- Leave 5% of the stand untreated, in patches 30 m or more in diameter. This will provide thermal cover.
- Where possible, locate openings near natural thickets that occur on the 5% of the area that was left untreated. Thickets will provide security cover and thermal cover, and will encourage favourable snow conditions in the forest

adjacent to openings.

- Space or thin 35% of the area to 150 to 175 stems per hectare and prune to 5.5-11 m above the ground. This will provide abundant forage now, and less forage but better snow interception later.
- If available, retain veterans or snags with lichens at a density of at least four per hectare to encourage arboreal lichens.

In both prescriptions, the pattern of treatments would have an important effect on deer capability. The openings, thickets, open-canopy forest, and snow interception forest should be interspersed in a fine-grained pattern rather than in three or four large and homogeneous blocks. This concept illustrates an important principle of managing for winter range values in young stands -- increased stand diversity means higher deer capability. The great horizontal and vertical variability of old growth cannot be replicated practically in thrifty stands, but because of variations in stocking rates, soil effects on stand growth, disease and insect attacks, aging, and weather, the stand conditions found naturally in old-growth ranges are also not everywhere ideal for deer. By designing the stand patterns of young-growth winter ranges and applying uniform forestry treatments in small patches, managers will be able to provide adequate or, perhaps, close to ideal interspersion of food and cover.

The recommended scale of the pattern is set by the size of the clearings (see Figure 2) and their proportional contribution to the winter range as a whole. In a stand that is 30-40 m in height during the period it acts as a winter range, clearings should be one-half to one tree-height, or 15-40 m, across (measured parallel to the direction of prevailing winds that accompany snowfalls). If clearings were approximately square and made up 5% of the total winter range area, each 15-m opening would be surrounded by an area of 0.43 ha containing snow interception forest, open-canopy forest, and at least one thicket. Clearings that were 40 m across would have surrounding stand complexes 3 ha in area.

Because the difficulty and expense of planning and conducting forestry operations will increase as the size of patches decreases, managers may prefer to make most clearings one tree-height wide. Openings should not be wider because of the tendency of larger clearings to accumulate deeper snow. Also, it should be remembered that smaller patches mean greater diversity and better deer capability. With clearings made oblong (with the long axis running perpendicular to wind direction) rather than square or circular, the total area of each opening and its associated forest patches can be increased without exceeding the recommended opening widths.

The topographical and biological features of winter range sites will often impose constraints on the potential stand pattern. For instance, the distribution and size of rock outcrops, windthrow patches, and root rot centres providing natural openings will seldom be ideal, because these features are usually clumped rather than scattered evenly across the landscape. Currently available data on deer movements provide little guidance on the extent to which deviations from the ideal size and pattern will reduce winter range capability, so the advice and judgement of biologists and foresters will be important in designing stand patterns for specific sites.

The optimum size for managed winter ranges is undetermined. The sizes of the areas used by individual deer during winter (winter home ranges) offer some guidance as to the minimum area needed. Recent data from 41 radio-collared deer on southern Vancouver Island showed that winter home range sizes varied widely among individuals -- from 2 to 700 ha. Using these data, it could be argued that a winter range block 2 ha in total size would be suitable for some deer, whereas only a block 700 ha or more in area would suit the majority of animals. However, neither of these extremes would be a practical management unit. A more realistic guideline is provided by the average home range size for resident deer (those occupying the same home ranges year-round) which ranged from 5 to 50 ha, depending on individual behavioural patterns and the number of locations used to calculate the home range area.

Further study will be needed to determine the optimum size for managed winter ranges, and to evaluate the potential benefits of creating a number of small, scattered ranges rather than fewer large ones. Differences in climates and plant communities among biogeoclimatic units will be important in determining the area that will support a given number of deer.

The prescriptions provided earlier in this section are intended to maximize the winter range values of the stands and do not consider negative effects on wood quality or quantity, other than in the recommendations for pruning. The recommended stocking levels, lower than those normally employed in coastal British Columbia, will result in reduced volumes per hectare at harvest, and the increased ring-width and branchiness of crop trees may decrease lumber values. However, the harvested trees will also be larger than normal, which should partially offset the volume and quality losses. The increase in deer production resulting from the specialized forest management regimes will provide an additional compensating benefit through increases in expenditures on hunting and other recreational activities.

4 THE PLANNING AND MANAGEMENT CONTEXT

Before a set of management prescriptions can be implemented, the planning and management context within which the prescriptions fit must be recognized -- in addition to the ecological and technical aspects already considered. This section sets that context and recommends a systematic approach to determining winter range needs and prescriptions. Tools and information sources needed to properly define the context are identified. Some of these are being prepared by the MOE or the Integrated Wildlife-Intensive Forestry Research Program; others are still just ideas. Anyone considering whether to begin a winter range management regime in a young stand should review the suggested components to determine if the expenditure of time and money needed to create a winter range is justified. Discussions with MOE regional staff and MOF district staff can provide valuable guidance.

4.1 Watershed Management Priorities

If expensive stand prescriptions are to be implemented, it is essential that they be applied in areas where they will produce the greatest returns. Thus, an overall management plan for Vancouver Island is required, which would rank watersheds by deer management priority and opportunity for stand treatment. This plan should consider the following factors: 1) snow conditions, average winter severity, and frequency of severe winters; 2) land tenure system; and 3) deer value and recreational opportunity considering supply, demand, and other management factors. Figures 3 and 4 illustrate how snowpack depth, snowpack duration, and frequency of severe winters could be used to develop a winter severity index and to stratify watersheds for management priority.

A Vancouver Island deer management plan is required. The MOE is preparing a draft of such a plan, which will define "deer production zones" based on criteria such as those listed above, and will rank the watersheds within the most productive zones by management priority.

4.2 Stand Evaluation for Watersheds

Once priorities have been established for watersheds, and it has been determined that winter range is needed in a given watershed, an evaluation procedure is required to determine the sites where winter ranges should be created. Sites within a watershed differ in their abilities to produce deer (to act as winter ranges) due to topography, soil condition, and position in the watershed. Stand history and adjacent forestry activities may also be important. These factors should be considered in determining the areas to treat within a watershed. The following steps should be taken:

1. Determine the deer and timber management objectives for the watershed.
2. Rate the topographic quality of all areas in the watershed. The

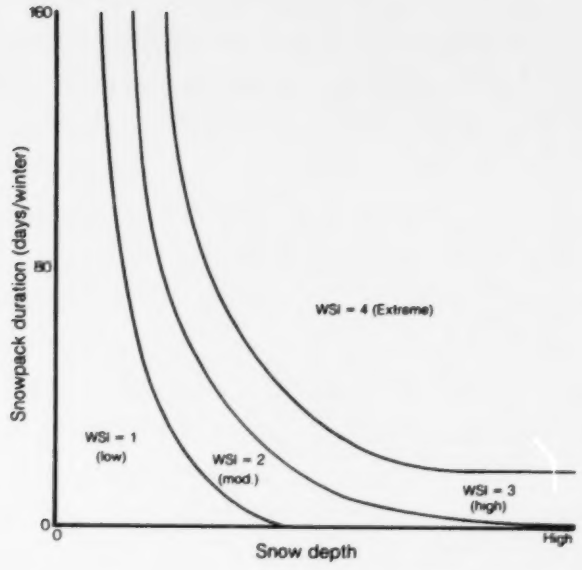

FIGURE 3. Snow depth and snowpack duration determine the winter severity index (WSI). Forestry practices would not be used to create winter range where WSI = 4.

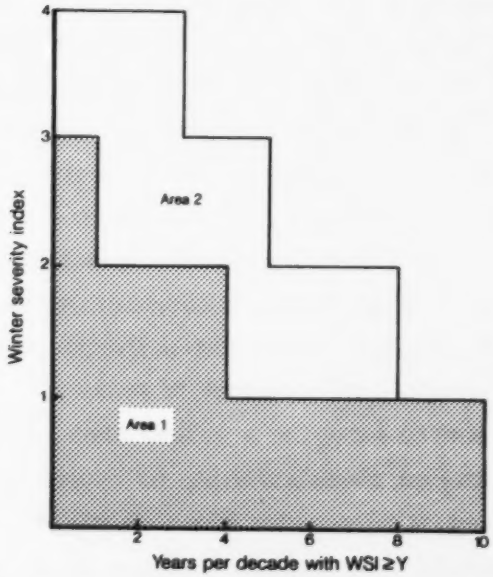

FIGURE 4. Two examples of the frequency of severe winters in different areas; Area 2 would not be an appropriate location for creating winter range through forestry practices.

preferred topographic features of deer winter ranges should be considered, including slope, elevation, aspect, position in watershed, and presence of rock outcrops (Section 2.1). Current forest cover should be ignored. Use a "High - Medium - Low" rating system.

3. Determine the size and shape of the areas rated High or Medium. Estimate how many deer they could produce if they were in ideal forest condition. These will be considered potential winter ranges.
4. Determine the current condition of forest cover and understory on each potential winter range. This would include calculating the area in each age class of forest and evaluating site history, site index, adjacent lichen sources, and natural openings caused by rock outcrops, root rot, or windthrow.
5. Estimate current deer capability by age class, and multiply by area to estimate present capability for the watershed. Consider habitat requirements in spring, summer, and fall as well as winter to ensure that all needs are met.
6. Compare current and ideal deer capabilities to management objectives for the watershed to determine the immediate need for intensive winter range management within the watershed.
7. Project the demand for deer over the planning period (20-40 years), and estimate the change in habitat capability that will occur without winter range creation.
8. Using the information gathered in points (1) through (7), review the opportunity for meeting deer and timber objectives with intensive winter range management. Consider the relative benefits and costs of retaining a small area of high-quality, old-growth winter range compared to managing a larger area of young-growth winter range that is lower quality.

A system is needed for predicting the increases in deer numbers that can be

anticipated under various treatment regimes. This system would consider, among other things, stand sizes and the availability of adjacent spring and summer range. It should involve simulation over time of stand size, age, juxtaposition, and capability.

9. Determine the management risk that is acceptable in attempting to produce given numbers of deer. Some deer will die in very severe winters, even in old-growth ranges (Figure 5). The manager must determine what level of potential deer loss is acceptable, and choose the type of winter range required. Criteria will include the expected winter weather conditions, the minimum number of deer considered to make up a "useable" population, and the costs in money, manpower, and amount of area treated in improving winter ranges from low to high quality.
10. Develop a watershed winter range management plan. Include ranking of winter ranges for intensive management, and objectives and actions for hunter harvest and predator management. Describe how deer will be monitored to evaluate the success of the plan, and describe how the plan will be changed as information is acquired (how adaptive management will be implemented).

This is an idealized procedure; the technology and knowledge needed for steps (5) through (8), in particular, are currently lacking, or are in the initial stages of development or acquisition. The Integrated Wildlife-Intensive Forestry Research Program is addressing some of these needs.

A manual is needed to guide wildlife and forest managers in evaluating winter range management opportunities and developing management plans for specific areas.

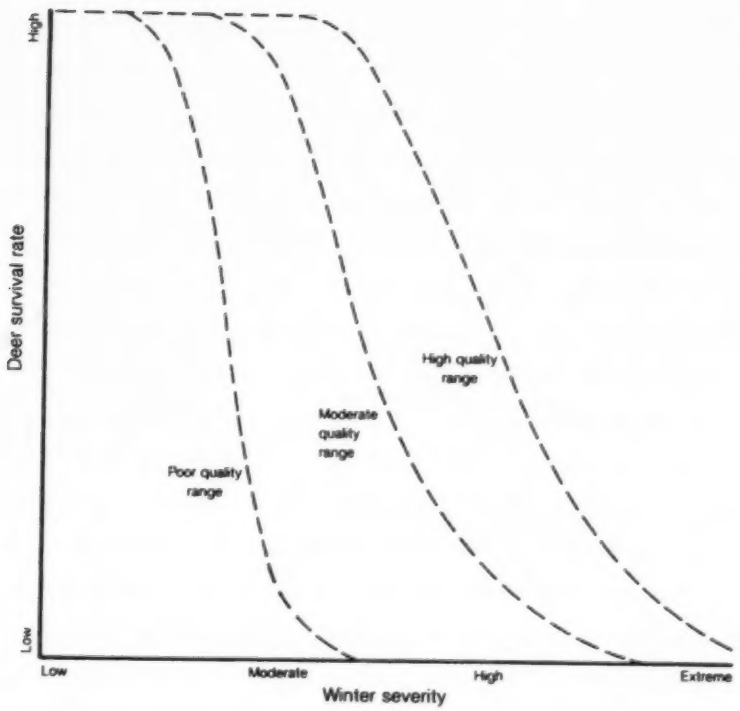

FIGURE 5. Deer survival as a function of winter severity on ranges of different quality. "Quality" refers to the capability of the area to meet winter requirements of deer.

5 SUMMARY

If silvicultural techniques can be used to develop young forests that will be suitable deer habitats in severe winters, the users of forests and wildlife will both benefit. Other options for dealing with winters of heavy snowfall, such as winter feeding or managing populations for sequences of mild winters, are not practical in most areas.

Although empirical evidence is still scanty, the processes linking winter weather, coastal forests, and deer suggest that forest management can provide a means of creating winter ranges in stands far younger than existing old-growth winter ranges. By instituting special regimes of harvesting, site preparation, regeneration, and stand tending on suitable sites, forest managers can control the features of stand canopy and understory that determine the winter habitat values of managed stands. In choosing a management regime for a site, managers should consider the number of deer needed to satisfy demand during the period the stand will function as winter range. Climatic and topographic factors determine the inherent capabilities of sites to act as winter range, and will restrict the options available.

The importance of various environmental factors of winter ranges (e.g. food versus cover) varies geographically depending on climate. Deer living in areas where winters are relatively mild and dry need different types of winter range than those living where winters are cold and wet. The stand features that most affect winter range quality can be modified with numerous forestry practices, but existing stand conditions and stand age impose important feasibility limitations.

This report has suggested forestry regimes that are expected to create good deer winter range in two types of coastal climates. It is conceivable, but not proven, that innovative management of young stands — including wide, early spacing (thinning) -- could result in acceptable deer winter ranges for moderate snowfall areas by the time the stands are 40 years old (at least on medium-quality or better sites). If one such stand (call it Stand A) was paired with a nearby area of equivalent

size (Stand B) that was planted when Stand A reached 40 years old, the two could be managed for a continual supply of deer winter range while allowing successive harvests of timber from the areas on an 80-year rotation. For example, if Stand A reached 40 years of age and began functioning as winter range in Year X, Stand B would become winter range at year X + 40, at which time Stand A could be harvested. The cycle of management would thus switch between the two stands at 40-year intervals.

This report presents three types of information: 1) the ecological and planning background to the problem of managing young forests as deer winter range; 2) a summary of current knowledge about deer, forests, and forestry; and 3) interpretations of this knowledge to form prescriptions aimed at providing suitable winter habitat in young stands. Uncertainties are inherent in the treatments prescribed and the future stand conditions forecast. The pattern and schedule of stand treatments described here are therefore not intended to be adopted immediately as a model by forest managers, and applied over large areas. Rather, these efforts to prescribe treatments are meant to encourage thinking and discussion amongst members of the British Columbia wildlife and forestry communities. Two demonstration areas are being established on Vancouver Island, in which the appropriate treatments will be carried out on small areas of approximately 5 ha (see Appendix 1). Tours through these demonstration areas are scheduled to begin in 1985. Subsequent operational trials and experiments are also planned to further develop and test the techniques of winter range management. The participation and co-operation of forest and wildlife managers from both industry and government will be needed in designing and carrying out these trials and experiments.

In attempting to manage coastal forests for integrated use, forest and wildlife managers are, as Jack Ward Thomas (1985) recently put it, "going places that we've never been". To reach those places as quickly as possible and avoid making too many wrong turns along the way, an adaptive management approach is needed. Best guesses must guide initial actions, and action is imperative, but it alone is not sufficient. The results of winter range treatments must be monitored, managers must learn from their

mistakes and successes, and approaches must be revised based on what is learned. Fueled with imagination and energy, and given a reasonable amount of time, this approach should carry the province closer to truly integrated management of forests and black-tailed deer.

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APPENDIX 1. Demonstration plan

Purpose:	To demonstrate two alternatives for the nature and pattern of treatments that would generate suitable deer winter range conditions in immature forests (i.e., less than rotation age). One demonstration will be located in a stand approximately 50 years old and suitable for commercial thinning, west of Youbou. The other will be in a 20-year-old stand in the Nimpkish Valley, and will be more suited to juvenile spacing (pre-commercial thinning). The Youbou stand will be part of the Cowichan Valley Demonstration Forest, near the largest population centres; while the Nimpkish Valley stand will be in an area where winters are snowier and many deferred old-growth winter ranges exist.
Target Group:	Managers and researchers in the fields of forestry and wildlife management, plus the interested public.
Co-operators:	Leadership will be provided by staff from the Ministry of Forests (J.B. Nyberg) and the Ministry of Environment (D. Janz). University of B.C. personnel (F.L. Bunnell) will contribute to demonstration prescriptions. Local supervision and direction will be required by Ministry of Forests district staff or forest company division staff depending on land tenure in the demonstration areas. Treatments will be carried out using special project staff (e.g. Canada Works).
Project Supervisor:	Brian Nyberg, Ministry of Forests, 4595 Canada Way, Burnaby, B.C. V5G 4L9 (660-7530).

Information Components:

1. Signs -- to be posted on-site
2. Information sheets -- for tour groups and others, describing purpose and nature of projects (with maps)
3. Tour material -- information sheets plus background literature (abstracts or summaries of Integrated Wildlife - Intensive Forestry Research or University of British Columbia reports).
4. Tour guides -- Researchers and managers from government and forest companies

Evaluation Plan:

Evaluation of the treatments will be conducted during 1985 and 1986 from the comments and suggestions of all participants in tours of the demonstration areas. After 1986, it is hoped that experiments and operational trials can be funded by a second phase of the Integrated Wildlife - Intensive Forestry Research Program so that long-term analyses of deer use and habitat features in managed winter ranges can be carried out.